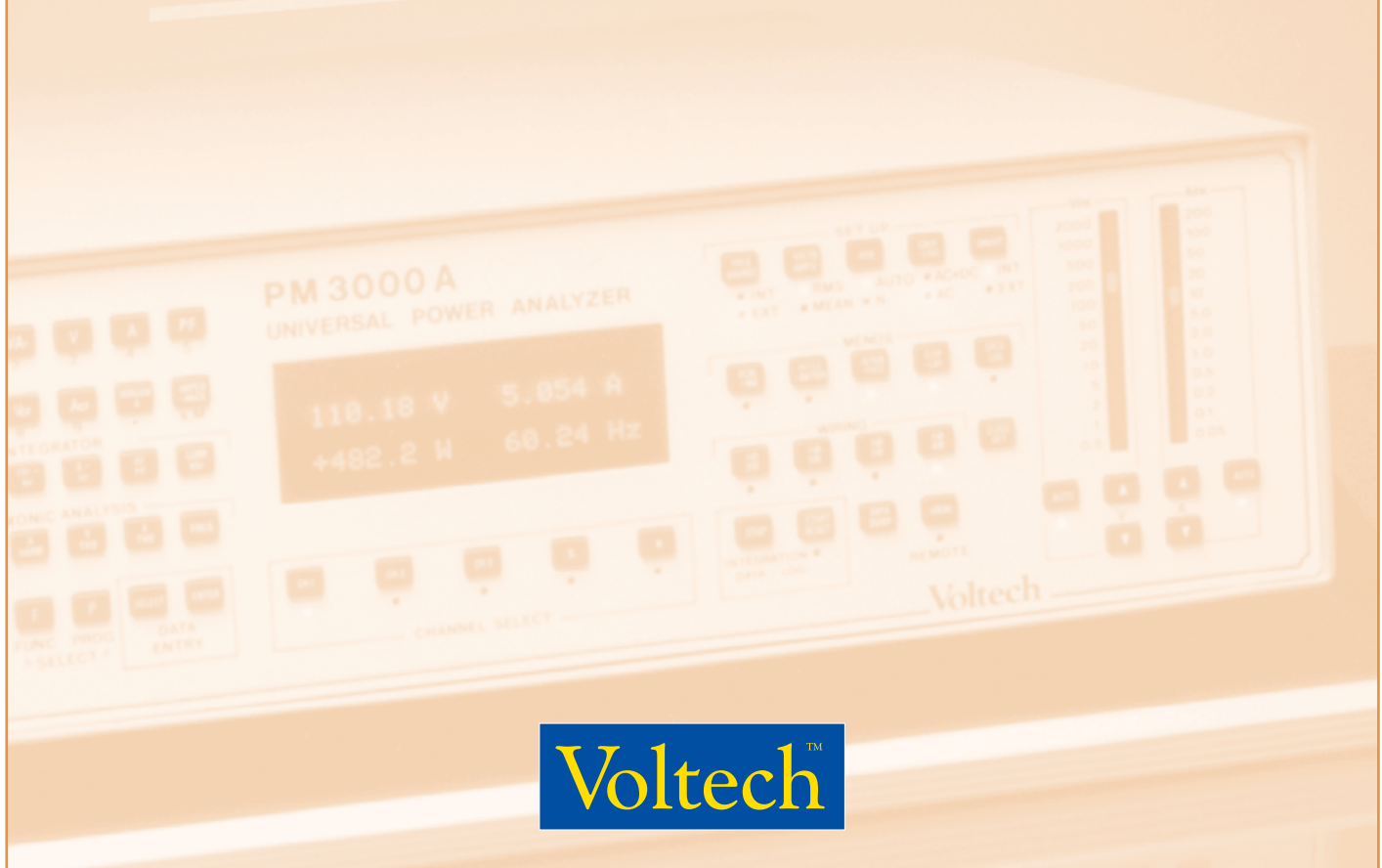


VOLTECHNOTES

IEC61000-3-12 Harmonic Measurements Up To 75A



IEC 61000-3-12 HARMONIC MEASUREMENTS UP TO 75A

Introduction

The legislative requirement to measure Harmonics and Flicker on equipment rated up to 16A rms is well known to organizations selling any type of electrical and electronic equipment in the European Community. IEC61000-3-12 defines limits for levels of harmonic current in equipment rated up to 75A. This technical note provides guidance for making measurements in accordance with the 61000-3-12 standard. An example spreadsheet for use with Voltech IEC software data is available from our website at www.voltech.com.

Relationship to 61000-3-2 (Harmonics $\leq 16A$)

The 61000-3-12 (<75A) standard uses the same basic methods, limit types and measurement methods of 61000-3-2 (<16A), and an understanding of those is assumed in this technical note. See the references for more information.

Compliance Testing to 3-12

Method

1. Connect up the power analyzer as shown in figure 1. The PM3000A power analyzer is suitable for direct measurements up to 30A rms. A precision current transformer such as the Voltech CT1000 (100:1) may be used to extend the measurement range up to 75A.

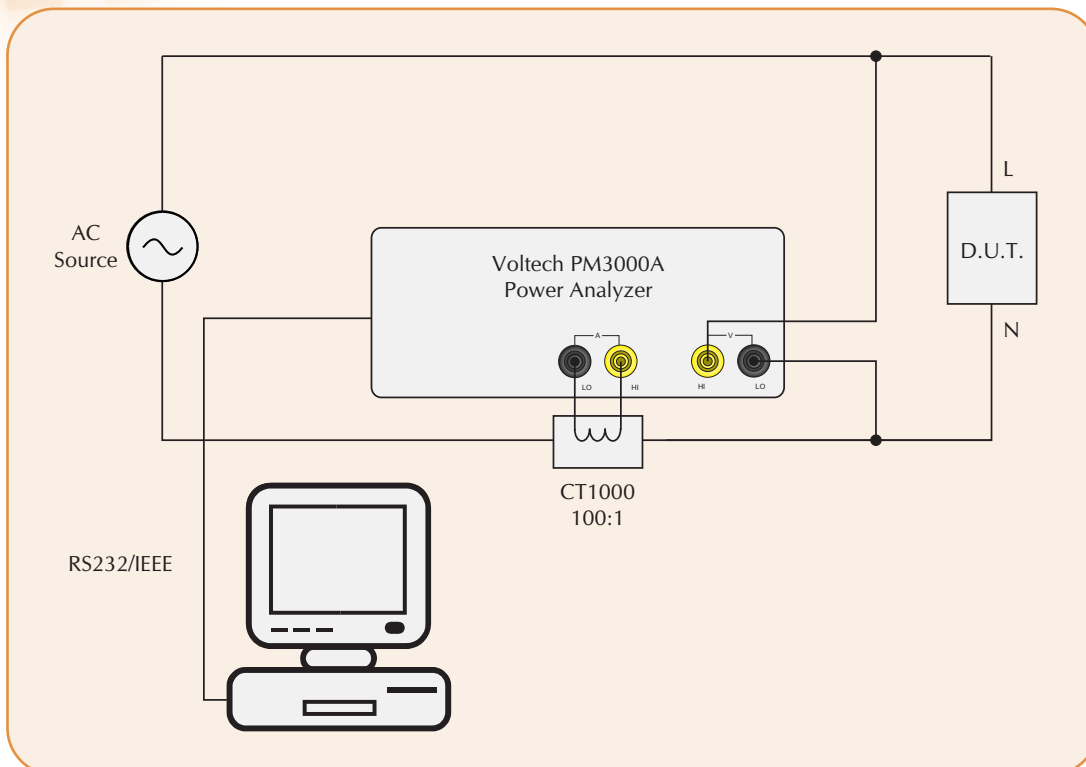


Figure 1. Measuring power and harmonics.

2. Make measurements as usual, using the power analyzer software. The class and other set-up details of the software are unimportant at this stage, although current scaling should be set if a current transformer has been used. At the end of the test, export the results from the software. The results may now be opened in a spreadsheet for manipulation in accordance with 61000-3-12, as follows,
3. Using the spreadsheet, calculate the following:

a) Total Harmonic Distortion (THD) =
$$\sqrt{\sum_{n=2}^{40} \left(\frac{I_n}{I_1} \right)^2}$$

b) Partial Weighted Harmonic Distortion (PWHD) =
$$\sqrt{\sum_{n=2}^{40} n \left(\frac{I_n}{I_1} \right)^2}$$

c) Percentage individual harmonics $I_2, I_3, I_4, I_5, \dots, I_{13}$

Where:

I_n is the average current harmonic, n , over the duration of the test from the spreadsheet.

I_1 is the average fundamental (1st harmonic) current over the duration of the test from the spreadsheet.

4. Compare the results with the tables in the next section.

Applying the Limits

Each of the calculated measurements is now compared with values given in rows of limits taken from tables of the standard. The comparison is made row by row. If every measured value is less than those in the row, then the requirements corresponding to that row have been met. Also every individual (not smoothed) harmonic result must not exceed 150% of the limit just as in 61000-3-2. The requirements are split into three stages, 1, 2 and 3, as described below.

Stage 1

Limits:

I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	I_{11}	I_{12}	I_{13}	THD	PWHD
4	21.6	2	10.7	1.3	7.2	1	3.8	0.8	3.1	0.7	2	23	23

If all measured values are below those given in the table above, then the requirement is that the instruction manual of the product shall state: "Equipment conforming to IEC61000-3-12, provided $R_{Sce\ min} = 33$ ". R_{Sce} is defined later but R_{Sce} is generally at least 33 for most commercial installations.

Stage 2

If the equipment does not meet the stage 1 requirements, compare the measured values against the appropriate table below. Start at the top of the table and work downwards until all the measured values are lower than those given on a particular row. Note the minimum R_{Sce} for that row. (It is acceptable to linearly interpret between table values in order to obtain an intermediate value of R_{Sce} , if required.)

Balanced Three-phase Equipment

Limits:

Min R_{sce}	I_2	I_4	I_5	I_6	I_7	I_8	I_{10}	I_{11}	I_{12}	I_{13}	THD	PWHD
33	8	4	10.7	2.7	7.2	2	1.6	3.1	1.3	2	13	22
66	8	4	14	2.7	9	2	1.6	5	1.3	3	16	25
120	8	4	19	2.7	12	2	1.6	7	1.3	4	22	28
250	8	4	31	2.7	20	2	1.6	12	1.3	7	37	38
350	8	4	40	2.7	25	2	1.6	15	1.3	10	48	45

Equipment Other Than Balanced Three-phase

Limits:

Min Rsce	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	I_{11}	I_{12}	I_{13}	THD	PWHD
33	8	21.6	4	10.7	2.7	7.2	2	3.8	1.6	3.1	1.3	2	23	23
66	8	24	4	13	2.7	8	2	5	1.6	4	1.3	3	26	26
120	8	27	4	15	2.7	10	2	6	1.6	5	1.3	4	30	30
250	8	35	4	20	2.7	13	2	9	1.6	8	1.3	6	40	40
350	8	41	4	24	2.7	15	2	12	1.6	10	1.3	8	47	47

Balanced Three-phase Equipment Under Specified Conditions

Limits:

Min Rsce	I_2	I_4	I_5	I_6	I_7	I_8	I_{10}	I_{11}	I_{12}	I_{13}	THD	PWHD
33	8	4	10.7	2.7	7.2	2	1.6	3.1	1.3	2	13	22
120	8	4	40	2.7	25	2	1.6	15	1.3	10	48	45

This table may be used only if one of the following conditions is met:

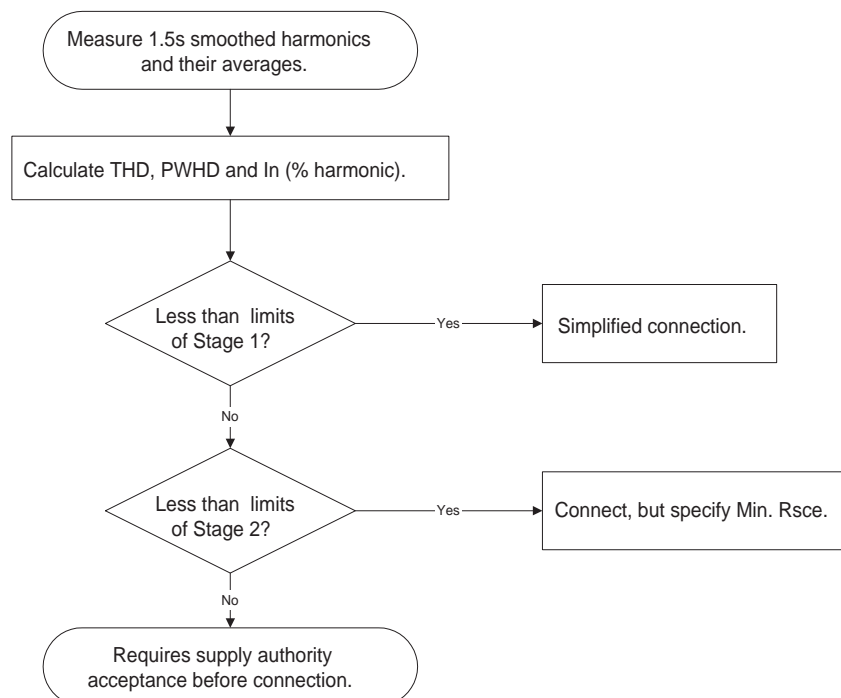
- The phase angle of the 5th harmonic current is in the range of 90 to 150° (typical of an uncontrolled diode bridge and smoothing capacitor).
- The design of the equipment is such that the phase angle of the 5th harmonic current has no preferential value over time and can take any value in the whole interval of 0 to 360° (typical of converters with fully controlled bridges).
- The 5th and 7th harmonic currents are each less than 5% of the reference fundamental current.

When a table value of R_{sce} can be found, the instruction manual of the product shall state: "Equipment conforming to IEC61000-3-12, provided $R_{sce} \text{ min} = xx$ ", where xx is the value found in the table. In addition, the user manual shall state that "there is a need for the supply authority to verify that the connection of this equipment is acceptable, based on the R_{sce} level and the predicted impact on the existing level of voltage harmonic distortion."

Stage 3

"For equipment complying neither with stage 1 or stage 2, the manufacturer shall state in the instruction manual and in a document available to a prospective user before purchasing the equipment, that it is necessary for the user to consult the supply authority for consent to connect the equipment...". Consent is required before connection, and the measurements of harmonics, THD and PWHD described here must be available to the electricity supplier.

61000-3-12 Testing Summary



A Practical Example

A piece of single-phase equipment is rated at 230V, 40A at 50Hz. The harmonics are measured using a PM3000A power analyzer and its associated PC software. The percentage individual currents and THD / PWHD are calculated according to the instructions given here. An example spreadsheet, showing how the calculations are done on data exported from Voltech software, is available from the support area of www.voltech.com.

Item	I ₂	I ₃	I ₄	I ₅	I ₆	I ₇	I ₈	I ₉	I ₁₀	I ₁₁	I ₁₂	I ₁₃	THD	PWHD
Stage 1 Limit	4	21.6	2	10.7	1.3	7.2	1	3.8	0.8	3.1	0.7	2	23	23
Measured Value	0.31	4.32	0.15	2.30	0.10	1.33	0.05	0.91	0.02	0.62	0.03	0.40	4.60	3.75

When these average measured values are compared with those of table 1, each of the measured value is below the limit. Also, every individual result shown on the complete spreadsheet is less than 150% of the limits in accordance with part 4.2.4 of the standard. Thus these results comply with the requirements of 'Stage 1: Simplified Connection'. All that is required is that the stage 1 declaration is made in the product's instruction manual.

Significance of $R_{sce\ min}$

The short-circuit ratio R_{sce} is related to the output impedance of the supply to which the equipment will be connected.

$$R_{sce\ min} = 230 / (Z \times I_{equ})$$

$$Z = 230 / (R_{sce\ min} \times I_{equ})$$

Where:

Z = supply output impedance

I_{equ} = rated line current

In this case,

$$Z_{max} = 230 / (33 \times 40)$$

$$Z_{max} = 174.2\ m\Omega$$



In terms of short-circuit current, I_{sc} , the supply must be rated at greater than

$$I_{sc \text{ min}} = V / Z_{\text{max}}$$

$$I_{sc \text{ min}} = 230 / 0.1742$$

$$I_{sc \text{ min}} = 1320\text{A}$$

Pre-compliance Testing

The full compliance testing methods described above use equipment and techniques that are in strict accordance with the requirements of the standard. Full compliance techniques are used by test houses and larger organizations to provide traceable certification that the tested equipment meets the standard.

Pre-compliance testing is often used during product design and development phases to provide useful measurements, using a less expensive test environment.

The Voltech PM3000A may be used without a fully compliant ac source to provide pre-compliance measurements. When making pre-compliance measurements, always ensure there is an adequate margin between the results and the limits before submitting the product for compliance testing.

Conclusions

Products rated at up to 75A per phase for connection within the European Community will need to comply with the harmonic limits described by IEC61000-3-12. The test method is basically identical to that of IEC61000-3-2, although different limits have been specified.

Versatile power measurement equipment such as the Voltech PM3000ACE can be used to making 61000-3-12 measurements simply with the addition of current transformers and some spreadsheet calculations. No hardware modifications are required.

The PM3000ACE is ideal for making either pre-compliance measurements from the normal ac supply or full-compliance measurements if used with a suitable ac source.

References

1. Voltech technical note "Understanding EN61000-3-2" (item no. 104-007).
2. This technical note is written as a guide to implementing the following standard and must be read in conjunction with it. In case of doubt, always refer to the latest available version of the relevant standard.

IEC61000-3-12 Limits - Limitation for harmonic currents produced by equipment connected to public low-voltage systems with input current $\leq 75A$ per phase and subject to restricted connection.

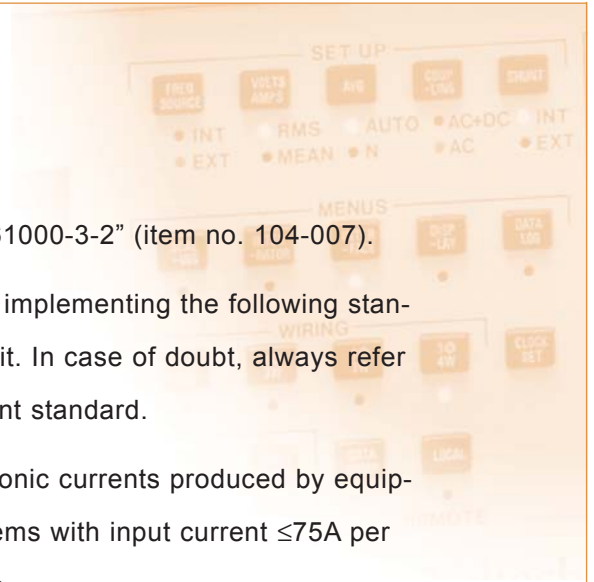
Note: 61000-3-12 is due for publication in 2004 and is the standard that will implement the following technical report:

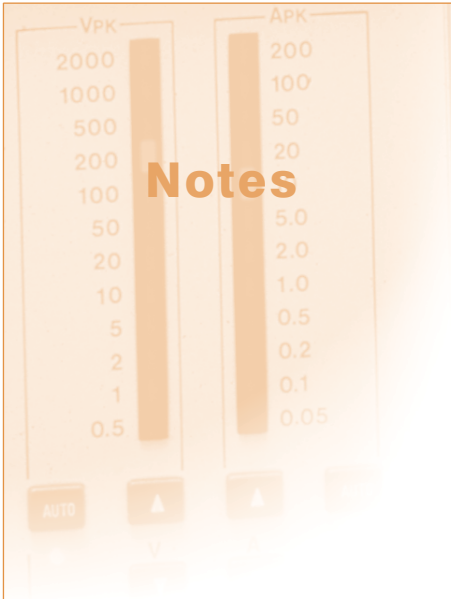
IEC61000-3-4:1998 Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16A.

IEC documents are available from www.iec.ch.

3. The Voltech IEC Software.

This PC software includes extensive reference and background material to the IEC harmonics and flicker standards within its help system. Fully working trial version available free of charge from www.voltech.com.





The Voltech PM Series of Power Analyzers

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